

UNCLASSIFIED

## Defense Technical Information Center Compilation Part Notice

ADP010571

TITLE: Cognitive and Sensory Limitations With  
Ageing

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: Operational Issues of Aging Crewmembers  
[les Consequences operationnelles du  
vieillissement des equipages]

To order the complete compilation report, use: ADA388423

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, ect. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:

ADP010557 thru ADP010582

UNCLASSIFIED

# Cognitive and sensory limitations with ageing

J.B.J. Riemersma

Department of Training and Instruction  
TNO Human Factors Research Institute  
P.O.Box 23  
3769 ZG Soesterberg, the Netherlands

## Summary

Demographic developments, characterised by 'ungreening' and 'greying' of the population at the same time, necessitate the reconsidering of early retirement schemes in general and possible those of military professionals as well.

Keeping people in the services at older ages asks for continued training and education as the only way to keep people fit for the jobs and to prevent that their skills and knowledge become obsolete. Training and education has to be compatible with the sensory and cognitive changes with age as well the tasks and roles ageing people are best suited for.

Changes in the sensory functions are undeniable: the eyes have lost their accommodation function at 60 and, due to yellowing of the eye-lens, discrimination of colour differences in the blue part of the spectrum is no longer possible. Compared to young people only a third of the energy reaches the retina in older subjects. These kinds of sensory deterioration start already at the age of about twenty and similar patterns can be shown for the auditory and vestibular functions.

For cognitive functions a somewhat more differentiated pattern has to be sketched with a lower functioning of working memory but no deterioration or even increasing functionality of the semantic memory and a still growing domain expertise.

Despite functional changes, in general no performance decrement in actual work is found. This can be explained in several ways. One is that older people compensate for their reduced capabilities by using different task strategies. This may result in a different pattern of underlying skills used in doing the job.

Based on rather scarce research results, especially scarce for the functioning of people between forty and sixty years of

age, still a number of recommendations for designing training and education for the older professional can be formulated. They derive partly from the sensory degradations with age, partly from the field of adult education. Findings in the latter field can be traced back to the changes in cognitive functioning with age. The challenge, society at large but also the military face, is to make best use of a by necessity growing segment of older professionals, in such a way that also after retirement the older professionals are better prepared for a longer, more independent and active life.

## Introduction

A growing concern with the loss of productive contributions by the elderly due to early retirement is paramount in most developed societies. The combined effects of greying of the population and the ungreening of it, threatens the balance between working and not working segments of the population.

For the military, this is a problem not yet fully recognised, because early retirement is part of most contracts of professional soldiers, the rationale usually derived from operational considerations. But when one realises that the problems of ageing workers nowadays are defined as problems of those above 40 years of age also the military should be concerned. In the remainder of this paper, I will first show the projected demographic developments. Next I will give an overview of the cognitive and sensory limitations with ageing, with a particular emphasis on learning abilities. Finally, I will present an overview of recommendations for the design of learning environments for ageing adults.

### Demographic developments

Of all future developments, demographic ones are among the best predictable. In all western countries, the effects of 'ungreening' and 'greying' will lead to a sharp increase of the ratio of non-productive versus productive population segments.

Compared with 1996, in the Netherlands this ratio will grow from 0.90 to 1.40 in 2040, an increase in burden of about 55 %. (Even more dramatic is the foreseen fourfold increase of people aged over 85 years of which more than half will need daily care). From these figures it is clear that the participation of the elderly in productive positions has to increase because the burden of early retirement schemes as they are customary in a number of western countries can no longer be sustained. This will only be effective however, when the ageing workers have the opportunity to update their skills and competencies by regular additional training and education or otherwise in order to sustain their productive capacity in a fast changing world. On the moment this is hindered by a phenomenon called: 'experience-concentration', well researched in the Netherlands and probably also relevant for the other Western countries.

### Experience-concentration.

Experience-concentration, a phenomenon, first described by Thijssen(1987), is characterised by its occurrence in the second part of the career, by a narrow focus of new experiences and learning activities, by a certain immobility and by a limited number of internal and external professional contacts. Main negative effects are a diminishing employability and a lower motivation to acquire new or updated qualifications by participating in educational activities.

Further research shows that the probable cause for this phenomenon lies in the way employees can interact with their organisational bosses. The latter usually operate from a stereotypical idea about ageing employees (hard to manage, only useable for long practised jobs) and since most middle managers have only a short time-horizon in their own ambitions, they

tend to get the most from older employees just by giving them the already well-practised tasks they have proven to do efficiently. Since they also think that they are better off with a 'young' department or workforce, the resources for further education are more readily allocated to the young employees than to the ageing ones, thereby creating a self-fulfilling prophecy that experience-concentration is a characteristic of older workers and not the result of a lack of age-consciousness career development interventions.

### Organisational strategies

Strategies for coping with the ageing employees vary among organisations. They can be characterised by two dimensions: accepting restricted employability or trying to enhance it; and time-horizon of intended effects: short or long.

Thijssen(1997) describes the resulting prototypical strategies as:

- replacement (accepting; short horizon)
- caring (accepting; long horizon)
- blocking ( not accepting; burden of employability lies with the employee)
- development (not accepting; employability is also a responsibility of the employer)

Although the propagated choice is for the development strategy, this one is certainly not the one most encountered in practice. So, societal and organisational factors are both relevant for the fate of the older worker. But what about his own (diminishing or constant) capacities to change his fate?

### Function-loss

One has to accept that most functions peak between 20-30 years of age (or even before) and that a number of them deteriorate fast, a number deteriorate slower and some of them deteriorate not at all. Relating this knowledge to work performance shows a somewhat paradoxical finding : work performance is hardly is affected by age. At least three different explanations can be offered. The first one is that one need not to have peak capabilities to do a certain job although an increase in workload may be the result.

The second one is compensation by

cumulating expertise, which off-sets any deterioration in function. A good example is the visual discrimination capabilities of well experienced medical analysts, which perform less on not job related tasks. A third explanation is the use of different task strategies to compensate for function losses. An example is the way experienced, but older, typists look further in the to be typed text to compensate for a slower movement planning (Salthouse, 1984).

This shows that the relation between function loss and performance is not as straight as one should expect. A second finding is that the variation in amount of deterioration is rather large, so age itself is often a bad predictor of this deterioration. This is due to a complex interaction between genetic differences and unique life experiences like life-style, health history, exposure to contaminants, type of work and the overall physical and cultural environment.

### **Sensory functions**

Sensory functions most obviously deteriorate with ageing. Starting at 20 years of age the eyes deteriorate in such measure, that at sixty almost no accommodation is possible and hardly any colour discrimination is possible in the blue zone. Furthermore, transmission of light through the eye-ball is only 33 % compared to healthy people 20 years old. Small details can no longer be detected, dark adaptation is substantially reduced, glare-effects are much larger. A comparable picture can be sketched for the auditory, smell, taste and vestibular functions. For the auditory functions the most obvious consequences are the lower ability for speech recognition and the lesser discrimination of sounds in a noisy environment.

Work as well as learning environments have to be adapted to these obvious changes in sensory functions in order to remain effective. Many problems can be directly related to these sensory deficits.

### **Cognitive functions**

Almost all memory effects of ageing are connected to the slower processing of new information by the working memory; other

memory functions do not degrade or get even better.

A distinction made by Howard & Howard (1997) is the following:

- working memory; allowing the short time allowed for pondering about newly acquired information
- episodic memory for remembering time-and-place coded experiences
- semantic memory for general knowledge about language and the world at large
- procedural memory for the knowledge how tasks have to be performed

Ageing effects are that the working memory deteriorates not so much in its capacity but in the ability to play with the contents of it. This can be illustrated by the difference in capability to 'hold' a certain number (e.g. a telephone-number) and the lesser capability to add in memory all the constituent numbers.

The episodic memory shows large deterioration with age. Crucial is the loss of remembrance of place-and-time cues of a memory. Such cues are instrumental for the ability to discriminate between general and specific information but also for discrimination between reliable and unreliable information.

The semantic memory does not show deterioration with ageing. Semantic knowledge and conceptual knowledge remain intact or even improve with old age. Only fast retrieval is sometimes a problem.

Procedural memory support all acquired behaviour but remains largely unconscious. Howard & Howard (1997) discuss three forms:

- classic conditioning
- skill acquisition
- priming

In classic conditioning (the Pavlov response) it is found that lengthening the time between unconditional and conditional stimulus gives conditioning effects comparable to younger subjects. The earlier idea that older people are less conditionable was proved wrong; only the *conditions* have to be adapted.

For skill acquisition a distinction has to be made between primarily perceptive-motor skills and cognitive skills. Perceptive-motor skills are more slowly acquired by

older people and they reach only lower skill levels. For the cognitive skills, acquisition is also slower but the ultimately acquired level is task dependant.

Priming is the memory phenomenon that due to earlier experiences with a certain item this item will more readily be remembered in the context of a new assignment compared to equally appropriate but not earlier experienced items. Asked to produce names of animals, animal names already addressed in an earlier context are more likely to emerge. The priming effect is not age specific, while the answers to the explicit question to name animal names, previously mentioned, do show an age effect (episodic memory).

### **Language and communication**

In many work situations language and communication skills are crucial. For oral communication the slower processing speed of the working memory presents a functional limitation for listening and comprehension. To make things worse, also the capacity to discriminate between 'signal' and 'noise' (the 'cocktail-party' effect) diminishes with age. These negative effects can (partly) be compensated by the accumulated knowledge and verbal capacity of the elderly. They use their knowledge of linguistic structures and probability of what will be said next to overcome these sensory and cognitive limitations.

Reading written material is a very complex process, consisting of roughly the decoding of the recognised letters in words, the retrieval of the meaning of words in the mental lexicon, the construction of the meaning of the strings of words in a sentence and finally the integration of the meanings of a string of sentences in a story scheme or a theme. This process is dependant on the written material at hand, but also on all the inferences added to it on the basis of earlier experiences.

Spilich (1985) discusses the age related changes in this process and concludes that the way of verbal instruction and design of manuals has to be adapted for the elderly.

### **Problem solving**

Problem solving is a capability, that clearly deteriorates with age, but only for new domains. Charness (1985) reports studies of expert players of bridge and chess which show that hardly any ageing effects can be found. Accumulated experience is transformed in a very domain specific expertise, relying much more on pattern recognition instead of analytically derived solutions, the latter being more vulnerable to the effects of slower processing speed or capacity of working memory. The development of this kind of fast pattern recognition takes however thousands of hours of playing.

The discussed losses in function can not only directly influence work performance, but also in a more indirect way. Panek (1997) describes an example: when the auditory function degrades, this can have as consequence that in a work setting orally given instructions are misunderstood, leading to an insufficient work result. This can provoke criticisms by colleagues because the unit target is not reached and this in its turn may lead to stress and subsequent (mental) withdrawal by the elder employee. The latter reaction strengthens the possible already existing stereotypic image of the older worker as slow, unable to perform and withdrawn. Such unwanted effects can only be prevented by insight into the possible function losses and the often simple measures to compensate for them in a work environment and by adapting the work to the specific capabilities and limitations of the elderly. To this belongs more opportunities for additional education and training instead of the more usual exclusion of these opportunities. Such schooling and additional training can only be effective however, when due care is given to the other ways of learning by the elder employees.

### **Learning by the elderly.**

Given this review of function losses with age, the image may emerge of the elder employee as half-blind, slow, forgetful and hardly employable. This is at variance

with the empirical findings of sustained productivity implying that function losses are compensated in some way. Already discussed is that elder employees need more time to learn something new, and that their level then acquired is task dependant.

Charness (1989) even states that: '...3 (additional) minutes of practice per year of age differences is all that it takes to eliminate age effects..'

This seems rather optimistic but underscores the permanent learning capability of the elderly as long as sufficient time and good coaching is provided.

Some research has been done on the functioning of elder commercial aeroplane pilots. This group is interesting because the public image of them is that pilots have to function at top level and thus have to be young. Also they have to learn to adapt to changes in the work environment since due to technological developments and societal changes in mobility patterns this environment changes rapidly (congestion's in the air, air traffic control, automation). Theoretically, one could expect an increase in accidents with older pilots involved, but the reality is different. Morrow & Leier (1997) report on accident statistics, showing that exposure corrected accident rates are high for younger pilots, decrease from 30-34 years of age to reach a plateau for pilots in their fifties and increase after the age of 63 is reached. The most likely explanation is the compensation of function losses by accumulated experience. This is no longer effective when one introduces new tasks and new aeroplanes. In adapting to large changes in procedures and aeroplane control older pilots do have more trouble of formerly acquired knowledge and habits than younger pilots. This is functionally caused by a diminished capability to ignore irrelevant information. Morrow & Leier (1997) advocate an approach in which the design of displays (visual as well as auditory) and air traffic procedures is adapted to the reductions in sensory and cognitive capabilities of the elder pilots and that conversion training departs from the already acquired knowledge and skills.

### **Compensatory mechanisms**

To offset sensory and cognitive limitations due to ageing, people use compensatory mechanisms. Earlier, it was mentioned how elder typists compensate for their slower motor programming capacity by looking further ahead in the to be typed text. Also Charness (1989) gives examples of the way elderly circumvent the problems associated with reduced capacity of the working memory by more reliance on pattern recognition and more specialised procedural knowledge. This not only enhances performance but also reduces the demands on attention heavy mechanisms. This exemplary evidence is now available for certain domains but is in no way general enough for work tasks as normally to be encountered. One has to conclude that much more research is needed to determine compensatory mechanisms in a variety of working environments, in order to be able to design effective education and training for the elder employees.

For the moment it seems wise to rely on the provision of a varied bundle of approaches for delivering training and education for the elderly, since they are by no means equally affected by age related general effects and do also have quite different histories. Still some general guidelines can be provided.

They are partly based on the general differences between the young and the elderly with regard to learning style, motivation, preferred way of information presentation and learning context and the match with earlier acquired knowledge and skills. Above this, one has to consider the possibility that for the elderly performance is based on a different profile of capabilities involved.

### **Adaptation of the learning environment to sensory function loss.**

A number of rather basic adaptations can be suggested:

- avoidance of all irrelevant, distracting and noisy information
- use of standard place and colour coding
- higher illumination of the workplace, such that glare is avoided.

- For verbal communication: bigger letters with more contrast, sanserif letters are recommended.
- Avoidance of colour coding in the blue area
- Suppression of distracting background noise
- Oral communication: slower and more redundant with correctly constructed sentences and a sequence avoiding the need to still remember earlier information for being able to interpret information given later

### **Adaptation of the learning environment to cognitive function losses.**

From the literature on the learning of adults a number of educational principles can be derived (Thijssen, 1996):

- Activation of the learner and avoidance of 'receptive' learning; this is explainable by the better remembrance by the elderly of information acquired during own activities as compared to classroom receptive learning.
- Avoiding straight memorisation; due to the weaker function of the episodic memory (retrieval cues) this is an ineffective strategy; when still straight forward information has to be remembered (pin codes for instance) mnemonics can be used; elderly are certainly able to use them.
- Providing feedback in very specific form
- Providing many feedback instances; the wealth of earlier experiences easily leads to wrong interpretations of the presented information so they have to be corrected as soon as possible.
- Providing a coherent frame of reference in which as much as possible relevant pre-knowledge is incorporated. In the change from typewriters to text processors much errors could be retraced to the old knowledge about typewriters no longer adequate for the text processing software. One can also argue that the use of ICT jargon as 'files' instead of 'documents' was not very helpful in making the transition.
- Making clear the relevance of acquiring the skills the course is

directed at; this is more readily accomplished when providing modules which allow for direct application on their own.

- Avoiding all forms of competition. This is counterproductive and can give rise to demotivation.
- Creating a social and supportive learning environment by providing guidance in a positive, protective way, by much social support and by stressing equality in the interactions of teacher/learner.
- Programming of learning activities such that any time pressure is avoided, learners can individualise the sequence of activities and can take their own time. The program has to be transparent, flexible and open. In such way the program can encompass the larger variability among the elderly, e.g. the differences in learning speed and preferences. Time pressure only magnifies age-effects and is counterproductive for storage of the learned material in memory.

### **Concluding remarks**

A hot topic is the introduction and use of ICT in numerous workplaces and for the access to services. This necessitates digital literacy of large segments of the population. On the moment, use of ICT by the elderly is scarce. Morell & Echt (1997) cannot explain this by a lack of motivation or capabilities with the elderly. They propagate the introduction of ICT in such a way that immediate, meaningful use is possible. ICT competencies thus have to be further developed by actively using it for doing one's work, solving real problems or getting access to needed services. Acquiring ICT competencies certainly can enrich one's life when getting older by enhanced self-supporting and stimulation of cognitive functioning. It can also help in overcoming reduced mobility and the often found reduction in social contacts.

Studies on developments during the course of life show large influences of work circumstances on cognitive development or retardation in the adult (Schooler & Schaie, 1987). Work, characterised by complexity, self-guidance and variety

promotes further cognitive development. Many work places do not yet show these characteristics, thereby inducing the reliance on long time routines and an earlier cognitive deterioration than is necessary. The societal challenge is to give much more attention to the potential of the growing segment of older workers and retired people. The known variability of the elderly on numerous characteristics should be recognised and translated in more individualised schemes of retirement.

### Literature:

- Allen, J.M. & M. Hart (1998). Training older workers: Implications for HRD/HPT Professionals. *Performance Improvement Quarterly* 11 (4) pp. 91-102.
- Charness, N. (1985). Aging and Problem-solving performance, In: N. Charness *Aging and Human performance*. Wiley, Chichester.
- Charness, N. (1989). Age and expertise: responding to Talland's challenge. In: L. Poon, D.C. Rubin, B.A. Wilson (Eds.) *Everyday cognition in adulthood and late life*. New York: Cambridge University Press, pp. 437-456.
- Fisk, A.D. & W.A. Rogers (1997). *Handbook of Human Factors and the Older Adult*. San Diego: Academic Press Inc.
- Howard, J.H. & D.V. Howard (1997). Learning and memory. In: A.D. Fisk & W.A. Rogers. *Handbook of Human Factors and the Older Adult*. San Diego: Academic Press Inc.
- Kausler, D.H. (1985). Episodic Memory: memorizing performance. In: N. Charness (ed) *Aging and Human Performance*. Chichester: Wiley.
- Morell, R.W. & K.R. Echt (1997). Designing written instructions for older adults: learning to use computers. In: A.D. Fisk & W.A. Rogers. *Handbook of Human Factors and the Older Adult*. San Diego: Academic Press Inc.
- Morrow, D. & V. Leier (1997). Aging, pilot performance and expertise. In: A.D. Fisk & W.A. Rogers. *Handbook of Human Factors and the Older Adult*. San Diego: Academic Press Inc.
- Panek, P.E. (1997). The older worker. In: A.D. Fisk & W.A. Rogers. *Handbook of Human Factors and the Older Adult*. San Diego: Academic Press Inc.
- Salthouse, T.A. (1984). Effects of age and skill in typing. *Journal of experimental psychology*, 113, pp. 345-371.
- Schooler, C. & K.W. Schaie (1987). *Cognitive functioning and social structure over the life course*. Norwood, NJ: Ablex.
- Spilich, G.J. (1985). Discourse comprehension across the span of life. In: Charness, N. *Aging and human performance*. Chichester: Wiley.
- Thijssen, J.G.L. (1987). *Het leren van de verouderende werknemer in veranderende organisaties*. [Learning of the ageing employee in changing organisations] Paper Congres Onderzoeks-Thema-Groep Onderwijsleerprocessen. Nijmegen: Katholieke Universiteit Nijmegen.
- Thijssen, J.G.L. (1996). *Leren, leeftijd en loopbaanperspectief*. [Learning, age and careerperspective. Dissertation] Proefschrift KUB.
- Thijssen, J.G.L. (1997). *Zicht op ouderenbeleid*. [Outline of a ageing population policy] Deventer: Kluwer Bedrijfsinformatie.